# MUNICIPAL SOLID WASTE

## ALBERTA'S UNTAPPED RESOURCE?

Alberta
ENVIRONMENT COUNCIL OF ALBERTA

86-01777/

# Terms of Reference

## FOR PUBLIC HEARINGS ON THE RECYCLING OF WASTE WITHIN THE PROVINCE OF ALBERTA

The Environment Council of Alberta is hereby requested to:

1) Enquire into the potential for the economic recycling of products presently disposed of as wastes; giving particular attention to:

   a) the potential, scope and obstacles to increased recycling by private sector business enterprises;

   b) the potential, scope and obstacles to increased recycling by volunteer organizations;

   c) the support role of local governments and the provincial government in facilitating recycling by the private sector and volunteer organizations, considering the potential reduction in waste disposal costs, the enhancement of the environment and privatization.

2) Consider the potential and comparative economics of the generation of energy from wastes when the alternative of the creation of useful goods and services from wastes is not feasible.

3) Hold public hearings at suitable locations throughout the province, and report to the Minister of Environment and the Lieutenant-Governor in Council on completion of the report.

*– Order In Council 106/85*

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Prepared By
Brian Free
Research Officer
Environment Council of Alberta

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Copies of this
report may be obtained
upon request to

Environment Council of Alberta
8th Floor Weber Centre
5555 Calgary Trail Southbound NW
Edmonton, Alberta
T6H 5P9
Telephone: (403) 427-5792

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# Preface

The Government of Alberta has asked the Environment Council of Alberta to hold public hearings on recycling of waste in Alberta. In particular, the Environment Council is to investigate the potential, scope, and obstacles to increased recycling as well as the potential for generating energy from waste should other alternatives be unsuitable.

As part of its preparation for these public hearings, the Environment Council has prepared a series of reports dealing with various aspects of recycling. This report provides information about Alberta's municipal solid waste and how it is currently managed. It is intended to aid the reader in identifying concerns and developing ideas about the future of recycling in Alberta. The Environment Council's public hearings will assist the Government of Alberta in determining future directions and policies to enhance recycling and improve waste management. The Environment Council needs your suggestions, opinions, and concerns.

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# 1. INTRODUCTION

Garbage...trash...refuse...waste.... No matter what we call it, everyone produces it. We generate refuse through our activities around the home, at our place of business, when we go shopping, and during our leisure time. Because it is such a "universal" phenomenon, solid waste collection and disposal has been identified as one of our society's common services. In urban centers, the efficient collection and disposal of large quantities of solid waste presents a constant challenge. However, some people view municipal solid waste not as a "problem" but as a readily available resource, providing valuable materials and other potential benefits, such as fuel for energy production.

What is municipal solid waste? It consists of any solid material or object that is discarded and introduced into the common waste management system. Municipal solid waste comes from homes, stores, offices, schools, and industry. It includes food wastes, newspapers, discarded appliances and consumer goods, bottles, cans, packaging material, broken toys, furniture, automobile tires, pieces of plastic, metal, clothing, wood, grass clippings.... The list goes on and on. Construction and demolition activity often contributes very large quantities of waste material. Liquid waste and hazardous industrial wastes are sometimes handled through special pathways, but frequently are included with conventional solid waste.

This report examines the nature of municipal solid waste in Alberta. There are many options available for modern waste management: materials recovery and recycling, incineration, composting, and many others. There are also many opportunities. What direction should Alberta's waste management take?

# 2. DESCRIPTION OF THE RESOURCE

In order to fully appreciate the potential value of Alberta's municipal solid waste, it is necessary to consider the characteristics of the solid waste stream. How much waste do Albertans generate? What types of materials do we discard? Are there seasonal or long-term trends that may affect the potential for resource recovery? These are important points to consider when discussing resource recovery.

## WASTE GENERATION

There is a wide range of information available about Alberta's solid waste; however, care must be taken in its interpretation and application. Most of the data are based upon the waste that is collected and disposed of in some systematic manner. Waste generation rates are usually calculated by dividing the amount of waste collected or disposed of by the number of people served by that collection or disposal system. These per capita generation rates include more than the personal waste generated in the home; they include the waste of the entire community, such as refuse from stores, offices, and construction sites. Most municipalities keep records of how much waste is handled by collection vehicles and licensed landfills often have weigh scales to record the quantity of waste brought in. These rates of waste collection or disposal are often described as waste generation rates. However, they are only measures of the solid waste handled by these community-based systems. Some refuse is discarded as litter, deposited on vacant land, burned in backyard barrels, and so on. In addition, some recyclable materials are already being diverted from the waste stream. Nevertheless, these rates probably represent the best estimates of the waste material available under current waste management practices and are reasonably accurate if their limitations are remembered.

Many factors affect the amount of solid waste generated by a community. These include population size and age structure, lifestyle, and even the season of the year. On an annual basis, the quantity of waste generated tends to peak in the spring when spring clean-up of homes and yards creates large amounts of refuse. Waste generation in the winter months is relatively low. Another factor affecting waste generation is community size. Measures of per capita waste generation tend to be higher in large urban centers than in smaller, rural communities. In large cities, bulky daily newspapers contribute large volumes to the waste stream, whereas smaller communities may only have small weekly newspapers. As well, concentrations of commercial and industrial outlets in large cities result in greater per capita generation rates from non-residential areas (Resource Integration Systems Ltd.

1980a). The nature and prevalence of various activities such as commerce, industry, agriculture, recreation, construction, and demolition also have a strong influence on waste generation. Many of these factors are very local in nature resulting in considerable variation in waste generation rates among communities.

Construction and demolition activity has a great effect on the amount of waste being deposited in landfills. This is illustrated by historical data from Edmonton and Calgary (Table 1). There was a substantial increase in the total waste disposed of during the late seventies with a peak occurring around 1980/81. At the peak, construction waste contributed close to 50 percent of the total waste going to landfill. Following the onset of the economic recession in the early eighties, construction activity declined. As a result, from 1980 to 1984 the total amount of solid waste landfilled in Edmonton and Calgary dropped by 55 percent and 32 percent respectively. By 1984, only about 20 percent of their solid waste came from construction activity. In Table 2, disposal rates at some regional waste disposal sites in Alberta are listed. The very high disposal rate for the Camrose Regional Landfill (5.84 kg/capita/day) is due to construction activity underway at the time of the survey. The average rate for the other disposal sites was only 2.21 kg/capita/day.

A large number of regional waste management studies have been conducted for the provincial government. In these studies, waste generation rates have been calculated to estimate the amount of waste that will be collected and disposed of in regional landfills. They include construction and demolition rubble. Because very few of the communities examined actually weigh the refuse currently being handled, various methods were employed to estimate these generation rates. A selection of these estimates is presented in Table 3. They range from 0.25 tonnes/capita/year in the rural setting of Municipal District No. 9 to 1.53 tonnes/capita/year in Leduc, which has a significant contribution from industrial operations in Nisku. The variability among these generation rates reflects the variation in waste generation resulting from local factors. However, the quality of the data and method of calculation may also have a significant influence on these statistics.

Bearing these considerations in mind, how much municipal solid waste is generated in Alberta? In view of the large, confusing collection of generation rates available in the literature and in government records, it was decided to calculate an Alberta rate from recent empirical data. For the purpose of this discussion, a per capita waste generation rate for Alberta was estimated from the quantity of refuse brought to representative landfill sites. This calculation includes residential, commercial, and industrial solid waste. Construction and demolition rubble, which is usually deposited with the general refuse, has been excluded. Although there may be some recyclable material in such rubble, it consists largely of material having little value for recycling under present conditions.

Actual 1984 disposal rates from several Alberta cities are presented in Table 4. They range from 2.60 kg/capita/day in Calgary to 1.77 kg/capita/day in Medicine Hat. In order to calculate an Alberta rate, the average rate from Edmonton and Calgary was used for large cities (more than 100,000 residents), and the average rate from Red Deer, Lethbridge, and Medicine Hat was applied to smaller cities (10,000 – 100,000). The disposal rate from the Flagstaff Regional Landfill Site, which services a representative mix of smaller communities and rural areas (J. Lapp 1985: pers. comm.) was applied to the rest of the province. The resulting estimate of solid waste generation in Alberta is *2.10 kg/capita/day* (Table 4).

**Table 1. Contribution of Construction and Demolition Activity to Municipal Solid Waste in Edmonton and Calgary**

| | Municipal Solid Waste ('000 tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
| Edmonton[1] | | | | | | | | |
| Construction/ Demolition | 379 | 372 | 520 | 626 | 647 | 347 | 162 | 115 |
| Other Waste | 569 | 623 | 655 | 685 | 657 | 549 | 478 | 482 |
| Total | 948 | 995 | 1,175 | 1,311 | 1,304 | 896 | 640 | 597 |
| Calgary[2] | | | | | | | | |
| Construction/ Demolition | 186 | 277 | 362 | 603 | 532 | 365 | 236 | 185 |
| Other Waste | 378 | 447 | 476 | 535 | 637 | 688 | 595 | 588 |
| Total | 563 | 724 | 839 | 1,138 | 1,169 | 1,052 | 831 | 773 |

Sources : [1] Unpublished data, Water and Sanitation Department, City of Edmonton
[2] Unpublished data, Engineering Department, City of Calgary

Note : "Total" may not equal the column sum as a result of rounding error.

Therefore, each Albertan generates about 0.766 tonnes (766 kg) of municipal solid waste per year for a provincial total of 1.8 million tonnes!

In the United States, there has been little, if any, change in the per capita generation rate over the past ten years (Alter 1980). Changes in waste generation may be more likely to occur at a local or regional level. Although per capita rates may be relatively stable (in the short term, at least), shifts in population and economic activity can be expected to influence the total quantity of refuse produced in Alberta.

## WASTE COMPOSITION

Results from many studies of municipal waste indicate that paper products usually form a major portion of the waste stream, ranging from around 30 percent to 50 percent by weight. Many kinds of paper are included in this category, such as newsprint, cardboard, ledger paper, writing paper, computer printout, and others. Yard waste, such as grass clippings, leaves, and shrubbery, is another major component. Other waste materials, such as metal, glass, plastic, and rubber, usually occur in small but consistent amounts.

**Table 2. Disposal Rates for Regional Landfill Sites (1983)**

| Regional Landfills | Average Disposal Rate[1] | |
|---|---|---|
| | kg/capita/day | tonnes/capita/year |
| Flagstaff | 2.11 | 0.77 |
| Crowsnest-Pincher Creek | 1.53 | 0.56 |
| Leduc and District | 2.14 | 0.78 |
| Lamont | 2.34 | 0.85 |
| Camrose | 5.84 | 2.13 |
| Sturgeon | 2.06 | 0.75 |
| Foothills | 2.60 | 0.95 |
| Average | 2.66 | 0.97 |

Source: Reid Crowther and Partners Ltd. 1985

[1] includes construction and demolition rubble

**Table 3. Estimates of Waste Generation Rates for Several Alberta Jurisdictions**

| Jurisdiction | Generation Rate | |
|---|---|---|
| | kg/capita/day | tonnes/capita/day |
| Cardston[1] | 2.10 | 0.77 |
| County of Beaver[2] | 2.36 | 0.86 |
| Crowsnest Pass[3] | 1.54 | 0.56 |
| Drayton Valley[4] | 2.58 | 0.94 |
| Drumheller[5] | 0.97 | 0.35 |
| Fort MacLeod[6] | 1.57 | 0.57 |
| Hinton[7] | 1.80 | 0.66 |
| Lacombe[3] | 2.06 | 0.75 |
| Leduc[3] | 4.20 | 1.53 |
| M.D. 9 (rural)[3] | 0.68 | 0.25 |
| Nanton[6] | 1.80 | 0.66 |
| Wainwright[3] | 1.36 | 0.50 |

Sources : Adapted from

[1] Underwood McLellan Ltd. 1983
[2] Reid Crowther and Partners Ltd. and Bissel and Associates Consultants Ltd. 1983
[3] Underwood McLellan Ltd. 1982
[4] Marshall Macklin Monaghan Western Ltd. 1981
[5] Alberta Environment 1978a
[6] Reid Crowther and Partners Ltd. 1985
[7] Dillon Consulting Engineers and Planners 1981

**Table 4. Generation of Municipal Solid Waste in Alberta**

| Community | Population[1] | Generation Rate[2] | | Quantity Generated |
|---|---|---|---|---|
| | | kg/capita/day | tonnes/capita/year | tonnes |
| Sample Large Cities | | | | |
| Edmonton | 560,085 | 2.34 | 0.854 | |
| Calgary | 619,814 | 2.60 | 0.949 | |
| All Large Cities | 1,179,899 | 2.47 | 0.902 | 1,060,000 |
| Sample Smaller Cities | | | | |
| Red Deer | 51,070 | 2.05 | 0.748 | |
| Lethbridge | 58,586 | 1.84 | 0.673 | |
| Medicine Hat | 41,493 | 1.77 | 0.656 | |
| All Smaller Cities (>10,000) | 315,839 | 1.89 | 0.689 | 218,000 |
| Sample Rural Area | | | | |
| County of Flagstaff | 10,000 | 1.69 | 0.617 | |
| All Small Communities and Rural Areas | 853,062 | 1.69 | 0.617 | 526,000 |
| Alberta | 2,348,800 | 2.10 | 0.766 | 1,800,000 |

Sources : [1]Alberta Treasury 1985
[2]Based on actual 1984 disposal information excluding construction and demolition rubble.

**Table 5. Relative Composition of Municipal Solid Waste**

| | Canada[1] | Edmonton | | | Calgary[4] | Wainwright[5] | |
|---|---|---|---|---|---|---|---|
| | | 1975[2] | 1976[3] | 1976/77[1] | | Commercial | Residential |
| | | | | (percentage) | | | |
| Paper | 36.4 | 48.4 | 54.3 | 32.2 | 41.5 | 37.0 | 27.8 |
| Glass | 6.6 | 1.6 | | 5.2 | 2.9 | 4.6 | 1.2 |
| Metal | 6.6 | 6.6 | 5.6 | 6.0 | 3.8 | 11.2 | 3.7 |
| Plastic | 4.6 | 4.3 | 5.9 | 4.7 | 1.2 | 1.3 | 2.2 |
| Textiles | 4.3* | 4.2 | 2.5 | 3.1* | 0.9 | 0.3 | 1.2 |
| Wood | 4.2 | 3.1 | 2.6 | 4.7 | 2.7 | 3.7 | 0.0 |
| Rubber | | | | | 0.3 | 0.0 | 0.4 |
| Food Waste/ Putrescibles | 27.6 | 3.9 | 1.4 | | 9.4 | 10.1 | 31.7 |
| Yard Waste | 6.1 | 27.2 | 17.1 | 33.4 | | | |
| Other | 3.5 | | 11.0 | 8.0 | 8.8 | 30.0 | 29.8 |
| | | | | 2.5 | 28.5 | 1.8 | 2.0 |

Sources: Adapted from

[1] Bird and Hale Ltd. et al. 1979

[2] Moell 1980

[3] City of Edmonton 1978

[4] City of Calgary, Engineering Department, unpublished report

[5] Underwood McLellan Ltd. 1982

*includes leather and rubber

During 1976 and 1977, a national survey was conducted of municipal solid waste from major Canadian communities (Bird and Hale Ltd. et al. 1979). Samples were collected at selected waste treatment and disposal sites and analyzed for weight, composition, and other characteristics. Street sweepings, sludges, and construction and demolition waste were not included in this survey because they "would tend to contaminate the waste stream and reduce its value for energy production or the recovery of materials for recycling..." (Bird and Hale Ltd. et al. 1979:v). The Bird and Hale report notes that the major components of the waste stream were surprisingly stable and they could not detect any significant regional differences. Only one component varied seasonally; a very large amount of yard waste is generated in the spring with very little during the winter months.

The composition of municipal solid waste has been examined in several Alberta communities. In Table 5, a selection of results is presented. As reported in other jurisdictions, paper products constitute a major component and other materials, such as glass, metal, plastic, textiles and wood, each contribute about 5 percent or less (by weight) to the waste stream. Yard waste, food waste, and "other materials" are often major categories; however, they are very much influenced by the types of waste materials that the researchers arbitrarily assigned to these categories. The variation in the yard-waste percentage determined in the three Edmonton surveys may reflect this bias or perhaps seasonal factors if the studies were conducted at different times of the year. In addition, these surveys are likely based on a small number of samples, a limited number of locations, or a short period of time. Considering the inherent variability in municipal solid waste, these figures may not be very precise. Nevertheless, they give a good general assessment of the waste stream.

The estimated 1.8 million tonnes of solid waste produced in Alberta may contain about 540,000 to 900,000 tonnes of paper products. However, different grades of paper have different value as recycled material. Similarly, only certain plastics can be melted down and re-formed into new products. Evidently, the categories traditionally used to describe waste composition may not be suitable for critical evaluation of the potential for resource recovery. More detailed analysis of local waste composition and accurate measures of waste generation are needed to accurately assess recycling potential.

# 3. MANAGING SOLID WASTE

As discussed in the preceding chapter, Albertans produce about 1.8 million tonnes of municipal solid waste each year. If not properly managed, this waste can present a hazard to our health and quality of life. What is involved in the management of solid waste? It generally consists of four elements: initial storage, collection, transportation, and final disposal. As waste management becomes more sophisticated, a fifth element, waste treatment or processing, is gaining importance. Many options are available for each of these elements and the design of waste management systems can be very complex.

## STORAGE

Once it is decided that some object or material is no longer of any value to us, it becomes garbage or waste. If it is not discarded immediately as litter, it is usually gathered in some designated place until it can be properly collected and disposed of. This temporary storage can take many forms. In single-family dwellings, the common methods of storage include metal or plastic garbage cans, plastic bags, paper bags, cardboard boxes, and so on. Some solid waste, such as newspapers, tree branches, and similar non-offensive garbage, may simply be secured in bundles. For multi-family dwellings, commercial outlets, industrial operations, and institutions, bulk containers are common. These metal bins come in various sizes, ranging from small, 2 cubic yard (1.5 $m^3$) bins to large, 50 cubic yard (38 $m^3$) containers. These storage bins are usually equipped with hinged lids to keep out the rain and snow, discourage animal visitors, and prevent wind-blown littering. They are designed to accommodate mechanical emptying or removal by special collection vehicles.

## COLLECTION

Collection of municipal solid waste involves a variety of methods, ranging from simple personal delivery with a private vehicle to sophisticated automated curbside collection. Household waste from residential areas is usually collected once per week at curbside or from back alleys. A variety of collection vehicles with one- to three-person crews can be used. Some of these vehicles are equipped with compacting units to compress the refuse as it is collected.

Service to multi-family dwellings, commercial outlets, and other large waste producers may be more frequent than that for home service. Storage bins are emptied by front-end loader trucks or some of the larger bins are removed from the site and taken directly to a transfer station or disposal site.

## TRANSPORTATION

Collection vehicles often haul directly to a disposal site. The distance to the site is a critical factor. Where the distance to the disposal site is great, the use of transfer stations is gaining popularity. Collection vehicles carry their loads to the nearest transfer station where the waste is transferred to larger, long-haul transport trucks. These trucks can carry loads from several collection vehicles, thereby reducing the haulage costs and allowing collection vehicles to spend more time collecting.

Transfer stations are designed to accommodate local needs. They may consist of a simple ramp which collection vehicles can drive up to empty their loads into a large bin. Once full, the bin can be emptied into a long-haul vehicle or taken away and replaced with an empty bin. At a more sophisticated station, the waste may be deposited on a concrete pad and pushed by a bulldozer through an opening in the floor into a trailer positioned below (MacKenzie n.d.). Other designs are possible, some of which incorporate waste treatment prior to shipment to the disposal site.

## WASTE TREATMENT

Waste treatment involves a wide variety of techniques and technologies. They are usually intended to:

1) reduce the volume of waste requiring disposal,
2) improve the ease-of-handling of the waste, and/or
3) facilitate materials or energy recovery from mixed refuse.

The most common waste treatment techniques include compaction, material size reduction, combustion, composting, and materials recovery.

### Compaction

Waste is compacted to reduce the volume and to increase the ease of handling. Portable home garbage compactors are available, although their use does not seem to be very widespread. These reduce the amount of storage space required for household garbage, but can present the garbage collectors with a heavy load if too much compacted garbage is placed in one container. Compaction more commonly occurs during collection and disposal of the waste. Collection vehicles are often equipped to compact their load during the collection process. This greatly increases the amount of refuse that the vehicle can carry and therefore reduces the number of trips to the disposal site or the number of vehicles required for waste collection. This increase in collection efficiency must be balanced against increased capital costs, as well as the operating and maintenance costs of these special vehicles.

Waste can also be compacted at transfer stations or disposal sites. The refuse is fed into a machine that compresses it into large rectangular bales. These bales are more easily handled than loose garbage and tend to reduce odor and litter problems. As well, baled garbage takes up less space in a landfill and eliminates air spaces in which methane gas from the decomposing garbage could accumulate. More commonly, loose refuse is compacted prior to covering it with soil at the landfill by driving over it with special heavy machinery.

This reduces the landfill space occupied by the waste and reduces the settling that often occurs after the site has been filled.

**Material Size Reduction**

Another form of solid waste treatment involves shredding, pulverizing, chopping, or otherwise breaking the waste up into smaller, more uniform pieces. The treated refuse is easier to handle, produces less odor and wind-blown litter, occupies less landfill space, and reduces the air spaces in the landfill. It also facilitates the recovery of certain materials from the mixed waste and improves its combustibility.

In a common size-reduction method, waste material is fed into a machine that shreds it into 15-cm (6-inch) pieces. Other machines can be used to hammer or pulverize the waste material. These treatments can take place at transfer stations, resource recovery centers, or disposal sites.

**Thermal Treatment**

Thermal treatment or "burning" of refuse has been practised for many years. It is a very effective way of reducing the amount of material requiring final disposal. The volume of waste can be reduced by as much as 90 percent (Rimberg 1975). Of particular interest in recent years is the recovery of energy from the incineration of solid waste. The heating value of municipal solid waste varies according to composition, moisture content, and other factors. The production of steam is commonly used to recover heat energy from the burning refuse. The steam can be used to drive generators to produce electricity, to run machines directly, or to produce heat for district heating.

Solid municipal waste can be burned directly or pre-treated to improve its fuel value. When it is pre-treated, the resulting product is often referred to as refuse-derived fuel (RDF). Pre-treatment commonly consists of shredding the waste and removing some of the non-combustibles. This latter step can include the removal of ferrous metals with magnets and the separation of a "light" fraction rich in paper and plastics using air classification. RDF can be burned by itself or co-fired with pulverized coal. Moell (1975: 14) suggests that "...properly prepared refuse may approach both the monetary and heating value of coal which is presently available from mines in the Edmonton area." The production of RDF is becoming an important use of municipal solid waste in the United States and Europe.

There are two basic processes used for thermal treatment of municipal solid waste: incineration and pyrolysis. Incineration involves burning material in the presence of sufficient oxygen for complete combustion, whereas pyrolysis involves thermal decomposition in the absence of oxygen.

*Incineration*

Three popular process designs for solid waste incinerators are mass burning, modular incineration, and semi-suspension burning (Hay 1984). Mass burning is a system in which the refuse is charged into a large chamber where it is burned with sufficient air for complete combustion. For modular incineration, there are two or more chambers. The waste is charged

into the primary chamber where initial combustion occurs. Insufficient oxygen is supplied for complete combustion at this stage, which is referred to as starved-air incineration or partial pyrolysis. The pyrolysis products and uncombusted material then move into the secondary chamber where excess air is supplied to complete the combustion. For semi-suspension burning, the waste is specially prepared by shredding and removing some of the heavy non-combustibles. This refuse-derived fuel is then injected into the incineration chamber and burned in suspension.

Another technology recently tested for burning solid waste is fluidized bed combustion. The refuse-derived fuel is burned in a very hot bed of fluidized sand. Hot air is forced up through the sand to "fluidize" it and supply the oxygen for combustion. Several facilities using this design have been built in Japan (Hay 1984).

*Pyrolysis*

Pyrolysis is another method of "burning" waste. It is conducted in an oxygen-free atmosphere at a temperature of about 815°C (1500°F) (Jackson 1974). The process uses heat to break down complex organic compounds, such as hydrocarbons and carbohydrates, into simpler forms. The pyrolysis of municipal solid waste produces a mixture of gases, oils, and solid char. The relative amounts of these products are affected by the rate and amount of heat applied and other factors. Approximately 6,000 standard cubic feet (170 $m^3$) of pyrolysis gas can be derived from a ton (0.907 tonnes) of solid waste (Moell 1975). This gas consists of methane, carbon dioxide, hydrogen, carbon monoxide, and water. Alternatively, a ton (0.907 tonnes) of solid waste can produce about one barrel (0.159 $m^3$) of synthetic oil (Moell 1975). The pyrolytic oils are clean-burning and have a heating value of around two-thirds of that of conventional fuel oils (Rogers 1981). These oils can also be used as feedstock in chemical manufacturing. The solid char that is produced can also be used as a fuel. In addition, it can be converted to activated carbon, a very useful product used in water purification and other processes.

**Materials Recovery**

There are two basic strategies for recovering discarded materials: at-source separation and retrieval from mixed refuse. For many materials, at-source separation is the only practicable method of recovery because, once mixed with the other waste, the material becomes contaminated and difficult to isolate. It is important to know the end use of the recovered material because the end use determines quality requirements. High-quality paper, certain plastics, non-ferrous metals, and glass are usually difficult to separate from the mixed refuse. At-source separation may be necessary to facilitate their recovery. Curbside collection of separated materials and articles is often a major component of at-source separation. Central depots can also be set up to receive separated recyclable materials.

Some materials can be successfully recovered from mixed refuse. A large array of both wet and dry separation techniques can be used for their selective removal. Raw waste can be hand-sorted from conveyor belts or mechanically sorted by various means. Often the waste is first shredded into smaller, more manageable pieces. Ferrous metals can be removed using large magnets. Light materials, such as paper and plastics, may be isolated using air suspension techniques (air classification). Various shaking tables, tumblers, screens, and other devices can be used to concentrate certain materials.

### Composting

Municipal solid waste contains a large proportion of organic matter that can be biologically decomposed under controlled conditions to produce compost. There are two alternative processes: aerobic (with air) and anaerobic (without air) digestion. Aerobic digestion of municipal refuse is usually favored because it proceeds more quickly, produces little objectionable odor, and achieves higher temperatures that will kill most pathogens (Golueke 1977).

For the production of compost, the refuse is prepared by shredding and removing most of the non-biodegradable material, such as metal, glass, plastic, and so on. The remaining material is arranged in piles or windrows and allowed to decompose for several days. The composting refuse is usually aerated by physically turning or re-piling. The action of natural micro-organisms converts the raw refuse into compost. Final processing may involve more shredding and screening of the compost.

The final product is an excellent soil conditioner. It can be very useful in the reclamation of land disturbed by poor farming practices, mining, and other industrial activities. Although its value as a fertilizer is limited, compost can be amended with sewage sludges to increase its nutrient content.

## WASTE DISPOSAL

No matter how extensively the solid waste is treated, there is still material to be disposed of. Ash from incinerators, other non-combustible material, non-recyclable material, and untreated refuse all require safe disposal. The most common method is land disposal in the form of landfilling. Disposal of personal waste on private property is also practiced, although it should be done in a manner that does not produce a nuisance or health hazard. In the past, local dumps were located in ravines, on riverbanks, in sloughs, and on other unused lands (MacKenzie n.d.). These dumps were often unsightly, unhealthy, and created environmental hazards. They are no longer acceptable by modern standards in Alberta.

Landfilling is currently the most popular method of waste disposal. It involves depositing the waste on the ground or in a trench, and periodically covering it with a layer of soil. The soil cover reduces odor and blowing litter and discourages animal visitors. The main attraction of landfilling is its simplicity and low cost of operation. However, growing difficulties in acquiring suitable sites for landfills, increasing costs, and environmental constraints are causing waste managers to consider alternative disposal methods.

# 4. SOLID WASTE MANAGEMENT IN ALBERTA

## RESPONSIBILITIES FOR WASTE MANAGEMENT

The main legislation governing the management of solid waste material is the Public Health Act of Alberta (SA 1984 c P-27.1). This Act was revised recently and some responsibilities have changed. The former Provincial Board of Health has been restructured to create the Public Health Advisory and Appeal Board. This new board hears appeals concerning decisions by Local Boards of Health and provides advice to the provincial government on public health matters. Under the new Act, regulations concerning waste facilities are issued by the Provincial Cabinet. The Waste Management Regulation (which supercedes the Provincial Board of Health Regulations Respecting the Control of Refuse Disposal Systems) governs the licensing and operation of waste management facilities. Such facilities include storage sites, sorting stations, transfer stations, and disposal sites.

Every municipality in Alberta is required to provide facilities for the safe and sanitary disposal of all waste created in the municipality. Three acceptable types of disposal sites are described in the Waste Management Regulation:

1) sanitary landfills – Municipal solid waste is deposited in the landfill and then compacted and covered with earth or other suitable cover material at least three times per week. Constant supervision of the operation is usually required and records of the quantity of waste being deposited are kept if the site serves 20,000 or more people. The site must be adequately fenced and regulations outline many safety and operational requirements.

2) modified landfills – Guidelines for modified landfills are less stringent than those for sanitary landfills. Waste material must be compacted and covered with earth or other suitable cover material at regular intervals (at least three times per year). No regular supervision of the site is required, although it must be fenced.

3) dry waste sites – These sites are designed to accept non-offensive waste material, such as yard waste, construction rubble, and discarded appliances and furniture. Eventually this refuse is covered with earth or other suitable cover material.

The regulation stipulates that communities or regions with populations of 10,000 or more shall operate a sanitary landfill for waste disposal. Smaller populations can be served

by modified landfills primarily because they do not have a sufficient tax base to afford the more expensive sanitary landfill system. Dry waste sites may be provided for non-toxic and non-putrescible waste for communities of any size.

Modified and sanitary landfills must be located at sites that are acceptable to the Local Board of Health. These sites must be located away from occupied dwellings, cemetaries, utility corridors, and other facilities and structures. Provisions for proper drainage are often required to prevent surface or groundwater pollution. Incinerators and industrial waste disposal sites are licensed under other legislation (the Clean Air and Clean Water Acts). Open burning at landfills does not require approval from Alberta Environment; however, a special permit must be obtained from the Local Board of Health for burning waste material at any waste management facility. A permit may be issued if the Local Board is satisfied that the fire will be confined to the facility and will not threaten public health.

Before the development of a waste management facility can begin, an approval from the Local Board of Health is required. Under current procedures, the Local Board refers the application for approval to several government agencies. All of the municipalities affected by the proposed facility and the appropriate Regional Planning Commission(s) review the application. If a Regional Planning Commission does not exist for the area, the Planning Branch of Alberta's Department of Municipal Affairs does the review.

Alberta Environment has a key role in assessing environmental aspects of a proposed facility. Soils and hydrology studies are conducted by the department or by consultants who present their studies for departmental review. Land-use conflicts are assessed and environmental input is co-ordinated by the Standards and Approvals Division.

Other provincial government departments may be involved in the referral process. For example, the Department of Energy and Natural Resources would see the application if Crown lands were affected. The Departments of Agriculture and Transportation also review some applications. If more than one municipality is participating in the proposed facility (for example, a regional waste management system), the application is reviewed by the Department of Social Services and Community Health and requires the Minister's approval.

Having received input through this referral system, the Local Board of Health may issue the approval for development of the facility. Before the facility begins operation, however, an operating permit is required from the Local Board. The application for this permit is seldom referred to any other agencies since extensive review of the facility has already been conducted.

Hauling personal waste to landfills by private citizens is common and may predominate in rural areas. Most municipalities, however, provide some form of community collection service. The municipality may own and operate the collection vehicles or may have a contract with a private company to provide this service. Sometimes there is a combination of public and private service.

The cost of collection and disposal services for residents is usually paid out of general municipal taxes at a flat rate. Residents pay this rate regardless of the amount of waste generated. In Edmonton, approximately one cent out of every tax dollar is spent on solid

waste management (City of Edmonton 1983). Commercial and industrial waste generators are often required to arrange for collection of their waste by a private waste hauler. Tipping fees, which are usually charged at the disposal site for commercial and industrial refuse, help to offset the operating costs of the landfill. Privately owned landfills are available in some areas.

On-site inspection and enforcement of regulations is performed by Local Board of Health Inspectors. Alberta Environment, in addition to reviewing applications for municipal landfill sites, actively promotes sound management of solid wastes through its Waste Management Branch. The Department provides financial and technical assistance to municipalities for waste management systems. The Regional Waste Management Assistance Program is intended to encourage the establishment of environmentally sound regional sanitary landfills and to reduce the reliance on small dumps and modified landfills. Financial and technical assistance is provided for the acquisition of land, preparation of the site, and purchase of major operating equipment. To receive this assistance, two or more municipalities plus the surrounding County, M.D., I.D. or Special Area form a Regional Waste Management Authority with the agreement to properly operate the site as a sanitary landfill. This voluntary program has attracted many interested communities. As of March, 1985, there were 18 regional systems. Twelve of them were operating regional landfills, while others were at various stages of development (Alberta Environment 1985a). Many other municipalities are considering this program through feasibility studies and related activities.

Alberta Environment is also involved in the reclamation of closed dumps and landfill sites and provides assistance for other forms of waste management, such as alternative technologies (for example, incinerators and pyrolysis units) and recycling programs. It also has a program for the safe collection and disposal or recycling of agricultural pesticide containers and for the collection of used lubricating oil for re-refining.

Special (hazardous) wastes are not normally handled by municipal collection and disposal systems. However, some industrial wastes may be accepted at municipal landfills or private landfills designed for that purpose. The Special Waste Management Corporation, a provincial Crown corporation, is now responsible for managing the collection and disposal of hazardous wastes. Oilfield wastes are under the jurisdiction of the provincial Energy Resources Conservation Board and some of these wastes are disposed of by deep-well injection.

Regional Planning Commissions are also active in the management of solid waste, primarily in conducting regional studies and assisting member municipalities in seeking solutions to common waste management problems (ORRPC 1983; RDRPC 1985). The federal government plays an active role in regulating hazardous wastes, particularly those that cross provincial borders. With respect to municipal solid waste, the federal government is responsible for waste management on federal land, such as national parks, military bases, and Indian reserves. Other federal involvement is directed towards research and financial and technical assistance.

## CURRENT SOLID WASTE MANAGEMENT SYSTEMS

A brief outline of solid waste management systems in Alberta is given below:

**Edmonton**

In 1984, Edmontonians produced about 597,000 tonnes of solid waste. Forty percent came from the commercial sector, 31 percent from residential, 20 percent from construction, and the remaining 10 percent from the industrial sector.

The collection of residential refuse is the responsibility of the City of Edmonton. Two-thirds is collected by city-owned vehicles and the remainder by private companies under contract with the City. Some commercial waste is also handled by this system. The collection of the remaining commercial refuse and all of the industrial and construction wastes is arranged by the waste generators with private collection companies.

The City operates two transfer stations to serve the City-managed collection system. At the Kennedale Transfer Station (128 Ave. and 58 St.), refuse is transferred from collection vehicles to long-haul semi-trailers. At the Strathcona Transfer Station (51 Ave. and 99 St.), the refuse is shredded before transfer. In 1984, about 16 percent of the residential waste was shredded. Until recently, the City operated a third transfer station in the west end (Coronation). This station has been discontinued because a nearby private landfill is now being used for direct disposal.

The City operates one sanitary landfill site at the northeastern fringe of Edmonton. The Cloverbar landfill site is an 81-hectare (200 ac) site near the North Saskatchewan River. Its present capacity will be adequate to mid-1989 (R. Neehall 1985: pers. comm.). There has been substantial community resistance to proposals for new landfill sites. A task force funded by the City and the Alberta government is currently investigating strategies for solid waste disposal in the Edmonton region.

Genstar Conservation Systems Ltd. operates a private landfill at its cement manufacturing operation near 128 Avenue and 163 Street. Mining of clay for cement manufacture provides an excavation for refuse disposal. In 1984, this site accepted 8.2 percent of the city's total solid waste (City of Edmonton 1984).

Several former landfill sites have been reclaimed. Rundle Golf Course is on the site of the former Beverly Landfill and another golf course is being constructed in Mill Woods on the South Side Landfill site. The Strathcona Science Centre is situated on the former Frontier Farms Landfill.

**Calgary**

The City of Calgary collects refuse from all single-family residences and some multi-family dwellings. The City also collects about 8 percent of the commercial waste. The remaining waste is collected by private contractors. No transfer stations are used in the Calgary system.

The City of Calgary operates three sanitary landfills and one dry disposal site. The Ogden dry disposal site (24 St. and 90 Ave. S.E.) receives mainly construction waste. In 1984, this site handled 91.2 percent of the city's construction and demolition rubble.

In 1984, there were 773,500 tonnes of solid waste deposited in Calgary landfills. Nearly one-quarter of this was construction rubble. The East Calgary sanitary landfill (68 St. and 17 Ave. S.E.) is also known as the Forest Lawn site. It covers approximately 320 hectares (800 ac) and handles half of the solid waste destined for sanitary landfill (City of Calgary 1984). There are special disposal trenches for automobile tires and a separate storage area for pesticide containers. Using large separation ponds, approximately 114,000 litres (30,000 gal) of waste oil is recovered annually from oil tank washings, tank truck washings, floor washings, and similar sources (T. Montgomery 1985: pers. comm.). The recovered oil is sold for re-refining. In addition, slurry from the manufacture of acetylene is stored in a separate pond and dewatered to recover the lime. The lime is used in conjunction with the disposal of dead animals. This site also accepts some industrial chemical wastes. A special permit is required and an on-site laboratory is used for testing the incoming waste.

The Shepard sanitary landfill (52 St. and 114 Ave. S.E.) is adjacent to City sewage lagoons. The Spy Hill sanitary landfill is located on the north side of the city (85 St. and 112 Ave. N.W.). Each site handles about one-quarter of the City's solid waste. Part of the Spy Hill site has been reclaimed for agricultural purposes. Other landfills that have been reclaimed include the Blackfoot and Nose Creek sites. These are now used for open storage, playing fields, and tennis courts.

**Lethbridge**

The City of Lethbridge waste management system services about 60,000 people. City-owned vehicles collect approximately 30 percent of the waste, private contractors about 50 percent, and private citizens haul about 20 percent of the total waste. About 20 percent of the waste is from residential sources and the rest is evenly split between commercial and industrial sources.

The City owns and operates a variety of collection vehicles. An experiment with automated refuse collection vehicles has been underway since 1983. In test neighborhoods, residents were given large plastic pails to hold their weekly refuse. These pails can be picked up and emptied by a mechanical arm on the collection vehicle. Preliminary results have been favorable, although community acceptance has been variable (W. Brodowski 1985: pers. comm.). The City of Lethbridge operates one sanitary landfill that will soon be closing. The City plans to haul its waste to a private landfill beginning in 1986 (W. Brodowski 1985: pers. comm.). A number of small landfills have been reclaimed in the City of Lethbridge. Most of them are being used for parking lots or storage areas.

**Red Deer**

In Red Deer, waste collection is conducted by a private contractor and not by the City. Refuse is also delivered to the landfill by private citizens. The City operates one sanitary landfill that has capacity for 8 to 10 more years (B. Higgins 1985: pers. comm.). It serves the City of Red Deer, nearby Red Deer County, Penhold, and Sylvan Lake. About 20 percent of the waste landfilled is from residential sources, 28 percent from downtown commercial operations, and 28 percent from construction and demolition activity. The remaining refuse is from private citizens and other sources.

**Medicine Hat**

Approximately 42,000 people are serviced by the City of Medicine Hat's waste management system. Collection of municipal solid waste is conducted by both City and private contractors. The City operates one sanitary landfill that has a capacity sufficient for about 10 more years (S. Mak 1985: pers. comm.).

**Lloydminster**

The City's population is approximately 16,000 people. Waste is collected by a private contractor and some refuse is delivered to the landfill site by private citizens. The site is operated as a modified landfill with no fencing or restricted hours of use. A solid waste management study is planned to consider a proper operation system for this site (J. Duckworth 1985 : pers. comm.).

**Grande Prairie**

The collection of residential solid waste in the City of Grande Prairie has been contracted to a private company. Commercial and industrial outlets also use a private hauler for waste collection. The current landfill site is approaching the limit of its capacity and a new sanitary landfill will be opened in 1986 (B. Tuttle 1985: pers. comm.). Approximately 28,000 people are served by the current site.

**Small Communities and Rural Areas**

Most small communities in Alberta are served by a licensed landfill site. These are usually classified as modified landfills, although some might barely meet that standard. In a survey of waste disposal practices in Alberta, only seven of the 100 modified landfill sites visited were found to be operating satisfactorily (Wood 1976). It is to be hoped that some improvements have been made since that 1976 survey. Nevertheless, there may yet be unlicensed dumps, known to local residents, but virtually unregulated, used in parts of Alberta.

According to 1981 census data, there were 195,284 Albertans or 8.7 percent of the population living on farms (Alberta Agriculture n.d.). Rural residents often dispose of some of their solid waste on their own property and therefore contribute less waste material to the community disposal system than most urban dwellers. Kitchen scraps are often fed to farm animals or pets and incinerable wastes are often burned in backyard barrels. The ashes and non-incinerable refuse, such as tin cans and glass jars, are deposited on the ground, in a pit or a ravine in a remote part of the farmstead. Some of the household waste may be trucked to the community landfill site.

The large quantities of agricultural waste from crops, livestock, machine shops, and so on, may be recycled, disposed of on the farmstead, or taken to the local landfill. However, for the purpose of this report, solid waste from agricultural activities will not be considered.

**National and Provincial Parks**

Solid waste management in national parks is the responsibility of the federal government and is not subject to provincial regulations. Their waste management systems vary according to local circumstances.

In Waterton National Park, domestic (putrescible) waste is incinerated and the ashes and non-offensive waste are landfilled in the park. It is planned to have all solid waste transported out of the park when the nearby Chief Mountain Regional Waste Management Authority begins its operation (J. Lapp 1985: pers. comm.).

The domestic waste from Banff National Park is transported to Calgary disposal sites via transfer stations in Banff and Lake Louise. Non-offensive trade waste is deposited at sites near Lake Louise and at Carrot Creek. The Carrot Creek site is receiving heavy use because of construction activity in the park. In addition, some waste material is being transported into the park to avoid tipping fees at other landfill sites. A new site is anticipated in the Cascade area and may feature the salvage of recyclable material (F. Zaal 1985: pers. comm.).

Jasper National Park has a landfill site near the townsite for domestic refuse. This site has electrified fencing for bear control and is covered with earth daily. A site for non-offensive waste, such as auto bodies, is located near Snaring Creek.

All of the solid waste from Elk Island National Park is transported to the Lacombe Landfill site. The small quantity of waste requiring disposal from Wood Buffalo National Park is taken to the landfill site at Fort Chipewyan.

The numerous provincial parks and recreation areas are much smaller than national parks and do not accommodate waste disposal sites within their boundaries. Solid waste is collected either by Parks personnel or by private contractors and taken to local landfill sites for disposal.

## COSTS OF SOLID WASTE MANAGEMENT

Collection is by far the most costly aspect of current waste management. In 1984, the cost of refuse collection in Alberta cities ranged from $31.35 per tonne in Medicine Hat to $46.81 per tonne in Red Deer (Table 6). Collection costs contribute from 75 to 89 percent of the total operating costs of waste management. A major factor in this is the labor-intensive nature of refuse collection.

The cost of operating a waste disposal site is a comparatively minor expense. Generally speaking, the more refuse being handled at a landfill site, the lower the operational cost per tonne. Therefore the landfilling costs for Edmonton, with only two landfill sites (Cloverbar and Genstar) serving a large population, are very low compared with other jurisdictions (Table 6). This economy of scale is one of the potential benefits to be gained by consolidating Alberta's many small rural dumps into larger regional landfills.

In order to offset some of the operating costs associated with a landfill, many municipalities charge "tipping fees" for certain waste material (for example, waste from commercial outlets, construction sites, and neighboring communities). In a survey of western Canada, tipping fees ranged from $4.40 per tonne in Saskatoon to $23.69 per tonne in Greater Vancouver (Genstar Conservation Systems Ltd. 1984). The City of Edmonton was charging $5.00 per tonne and the City of Calgary tipping fee was $6.65 per tonne, both of which exceed the estimated costs (Genstar Conservation Systems Ltd. 1984).

**Table 6. Operating Costs of Solid Waste Management in Alberta Cities for 1984**

| City | Operating Costs (dollars/tonne) | | | |
|---|---|---|---|---|
| | Collection | Transfer Stations | Landfill | Total |
| Edmonton[1] | 41.33 | 12.02 | 1.94 | 55.29 |
| Calgary[2] | 36.53 | – | 4.36 | 40.89 |
| Lethbridge[3] | 45.57 | – | 5.65 | 51.22 |
| Red Deer[4] | 46.81 | – | 7.00 | 53.81 |
| Medicine Hat[5] | 31.35 | – | 8.94 | 40.30 |

Sources : [1] Annual Reports, Department of Waste and Sanitation, City of Edmonton
[2] Annual Reports, Department of Engineering, City of Calgary
[3] Brodowski 1984 : Table 3.1
[4] Unpublished data, Department of Public Works, City of Red Deer
[5] Unpublished data, Department of Public Works, City of Medicine Hat

As the total amount of solid waste generated in Alberta grows and the sophistication of our waste management systems increases, the total costs associated with solid waste management also rise. Much of the recorded increase in waste management costs is due to inflation. In Table 7, past operating costs (on a per-tonne basis) are presented for the Edmonton and Calgary municipal systems. These costs have been adjusted to 1984 dollars using the inflationary rate for government expenditures on goods and services. The reader is cautioned that these are operating costs only and do not represent the total costs involved. Furthermore, differences in accounting and waste management practices (for example, the contribution from the commercial sector) will complicate comparisons between these cities.

Nevertheless, it is apparent that in real terms the collection costs per tonne of waste have declined from 1974 to 1984, especially in Calgary. This is likely a result of increased collection efficiency; computers now assist in determining efficient collection routes, collection vehicles are better designed to meet specific uses, and workforce productivity has greatly improved (T. Montgomery and R. Neehall 1985: pers. comm.). An apparent increase in the cost of landfill operation is likely due to better environmental design, greater staff requirements for supervision and administration, and so on (R. Neehall 1985: pers. comm.).

In addition to operating costs, an important factor that must be figured into this assessment is the capital costs. Collection vehicles must be purchased and replaced when necessary. The acquisition of land for new landfill sites is a *major* cost associated with landfilling that is often overlooked. This runs counter to the economy of scale discussed previously. For large landfill sites, land acquisition is expensive and, indeed, finding a large,

suitable parcel of land in close proximity to a city or town is becoming increasingly difficult. Other frequently overlooked costs include site preparation before start-up and site reclamation following final closure. The high cost and scarcity of suitable land is a serious concern in some areas of the province.

**Table 7. Operating Costs of Solid Waste Management in Edmonton and Calgary**

Reported Costs (dollars/tonne)

| | Edmonton[1] | | | Calgary[2] | | |
|---|---|---|---|---|---|---|
| | 1974 | 1979 | 1984 | 1974 | 1979 | 1984 |
| Collection | 16.56 | 25.41 | 41.33 | 23.26 | 27.47 | 36.53 |
| Transfer Stations | 4.39 | 7.41 | 12.2 | – | – | – |
| Landfill | 0.44 | 0.88 | 1.94 | 1.47 | 2.28 | 4.36 |
| Total | 21.39 | 33.70 | 55.29 | 24.73 | 29.75 | 40.89 |

Adjusted Costs (1984 dollars/tonne)*

| | Edmonton | | | Calgary | | |
|---|---|---|---|---|---|---|
| | 1974 | 1979 | 1984 | 1974 | 1979 | 1984 |
| Collection | 45.71 | 41.23 | 42.33 | 64.20 | 44.58 | 36.53 |
| Transfer Stations | 12.12 | 12.02 | 12.02 | – | – | – |
| Landfill | 1.21 | 1.43 | 1.94 | 4.06 | 3.70 | 4.36 |
| Total | 59.04 | 54.68 | 55.29 | 68.26 | 48.28 | 40.89 |

Sources: [1]Annual Reports, Department of Water and Sanitation, City of Edmonton
[2] Annual Reports, Department of Engineering, City of Calgary

*Adjusted to 1984 dollars by adding the Statistics Canada inflationary rate for government expenditures for goods and services;
176.02% (for 1974 data)
62.27% (for 1979 data)

# 5. FUTURE DIRECTIONS FOR ALBERTA

We have considered the current state of solid waste management in Alberta. However, solid waste management is in a state of flux, responding to changing needs and societal concerns. What direction should our waste management system take? Some options are discussed briefly below.

## LANDFILLING

Sanitary landfilling will probably continue to be the method for final disposal for most of Alberta's municipal solid waste in the foreseeable future. The shift from open dumps to sanitary landfills is well underway. The provincial government has a program to encourage the development of regional landfill sites and eliminate and reclaim the many small local dumps. However, sanitary landfilling is not the "panacea" for solid waste management in Alberta. Landfill sites have finite capacities, often sufficient for only 10 to 20 years. Locating new sites is an ongoing exercise. Rising land prices, stricter environmental constraints, and elusive community acceptance make it more and more difficult for municipalities to find new, acceptable sites.

Much of the current concern about landfilling focuses on environmental problems, such as contamination of soil and groundwater. Over time, the refuse buried in a landfill undergoes changes; materials break down, decompose, and interact. Rainwater and meltwater percolate through the soil and refuse and, at some sites, groundwater may come into direct contact with the waste material. The water leaches chemicals and other substances from the landfill and these leachates can contaminate the soil and groundwater.

There are many ways to reduce the potential for environmental contamination from landfills. Careful site selection can greatly reduce environmental problems. Proper site preparation may require sophisticated drainage and leachate collection, special liners to isolate the refuse, and other engineering techniques. Certain waste treatments, such as incineration and pyrolysis, can greatly reduce the volume of solid waste and render the material less likely to contaminate the environment.

In 1981, the federal and provincial governments sponsored an inventory of solid waste disposal sites in Alberta. Of the 1,152 sites identified (705 active and 447 inactive sites), 165 sites were determined to potentially have environmental problems (MacLaren Plansearch Lavalin 1982). Further assessments are planned for 18 of these sites (Alberta Environment 1985b).

There is growing pressure to reduce the volume of solid waste requiring final disposal. Recycling, incineration, shredding – there are many proven techniques that should be considered. As the cost of current waste management methods increases, different forms of waste treatment become economically more attractive, especially those that can generate revenues, such as materials recovery, energy-from-waste, pyrolysis, and composting.

## MATERIALS RECOVERY

At-source separation of certain waste materials is already a routine part of our lifestyle. Many households bundle their newspapers and stockpile their beer, wine, and liquor bottles and save them for paper or bottle drives for local charities, or deliver them personally to recycling depots. Another Environment Council report in this series, *A Social Perspective of Recycling in Alberta* (Free n.d.), discusses many of the ways in which Albertans currently recycle. Could more material be recovered in this way?

Powell (1984) reports that about 500 communities in North America have curbside collection service for recyclable materials. Several municipalities in Canada have instituted this service. In Fredericton, New Brunswick, paper, glass, metals, and plastics are collected for recycling (Carson 1984). Several communities in Ontario have curbside collection. Perhaps the most successful of these services is operated by Total Recycling Systems Ltd., a private company in Kitchener, Ontario. Participation in some neighborhoods is as high as 80 percent (Ludolph 1984). Newspapers, glass bottles and jars, tin cans, steel pop cans, and used motor oil are collected. To facilitate collection, each household has been given a blue plastic box with a prominent "We Recycle" logo on it. Participants are asked to take off the labels and flatten their tin cans, remove any metal or plastic from the glass bottles and place the cans and bottles together in the Blue Box. Newspapers are bundled and placed on top and used motor oil is stored in plastic jugs that can be placed beside the Blue Box on collection day. A special compartmentalized truck is used to collect these recyclable materials. A regular garbage truck collects the other household waste. In the first three months of 1984, 11.81 percent of Kitchener's solid waste was diverted to recycling (Kairow 1984).

In 1976, a test project for the separate collection of recyclable materials was conducted in Drayton Valley by Alberta Environment. During this one-year experiment, participants were given two large cans for storing discarded glass and metal, and paper was to be bundled separately. Special collection days were designated for each of these materials. Community support for this program was disappointing, with a maximum of 140 households (8.2 percent) participating (Alberta Environment 1978b). Inadequate publicity and the lack of a local citizen or group promoting the project were cited as possible reasons for its failure (Alberta Environment 1978b).

In Calgary, Foothills Conservation and Recycling Ltd. conducts a monthly curbside pick-up of newspapers in certain neighborhoods of the city. This collection is co-sponsored by a community group, such as the Boy Scouts, and community support has been very good (J. Ellacott 1985: pers. comm.). Although community paper drives are not uncommon in Alberta, this may be the only example of *regular* curbside collection of recyclables in Alberta.

In addition to curbside collection, separated materials can be taken to recycling depots. Large bins for newspaper collection are placed at convenient locations, such as shopping malls and churches. Sponsorship by community service groups encourages people to bring their newspapers in. In Hanna, the Hanna Young Lions Club has implemented a successful newspaper collection system and has expanded into cardboard and waste oil collection (Richardson n.d.). There are also many recycling depots in Alberta. For example, there are about 185 bottle depots in Alberta that accept beverage containers (Taylor n.d.). Several vocational rehabilitation centers for disabled adults operate recycling depots where papers, bottles, and other recyclables are taken in and sorted for sale to industry. Many of the province's sanitary landfill sites have special areas for "white goods" (major appliances), rubber tires, and other materials as well as collection tanks for used motor oil. At the Flagstaff Regional Landfill site, rubber tires are being stockpiled and a system has been established for the collection of used motor oil (Likness n.d.).

As an alternative to at-source separation, materials can be recovered from the mixed waste stream. This can be done at processing centers located at transfer stations or landfill sites. The waste is usually fed onto conveyor belts and carried through several treatment and sorting processes, such as screening, hand-sorting, shredding, magnetic separation, air classification, and others. Such processing can be costly in terms of labor, capital, operation, and maintenance. However, less commitment and effort is required from the waste generators.

The Ontario Centre for Resource Recovery is a working-scale experimental facility for recovering materials from a small portion of Toronto's municipal solid waste. It is designed to handle 825 tonnes of refuse per day (Vaughn and Parker 1983). Only one-third of the waste is processed for resource recovery and the rest is simply transferred for hauling to a landfill site. The facility is designed to recover paper, ferrous and non-ferrous metals, plastics, and glass. It can also produce compost and refuse-derived fuel. Approximately 200 tonnes of refuse are being processed each day, which constitutes less than 5 percent of Toronto's solid waste output. This working facility has been useful in revealing some of the problems that can be encountered during the processing of mixed waste. Fires and explosions during the shredding operation have required alterations to ensure worker safety. Magnetic separation collected the ferrous metal, but the product was found to contain too much non-metallic material. A gas-fired furnace was added to burn off these contaminants and the recovered metal is now marketable. Manual extraction of paper and cardboard from the mixed waste appears to be uneconomical and the marketing of the compost can be difficult (Vaughn and Parker 1983). Many of the problems encountered can be solved with adjustments in design and operation, although it is unlikely ever to be a profitable venture.

## INCINERATION

Another important characteristic of solid waste is its value as an energy source. Generally speaking, approximately 80 to 90 percent of municipal solid waste is combustible and there is a long-term trend of an increasing proportion of combustibles in the waste stream, primarily in the form of paper and plastics (Rimberg 1975). One tonne of municipal solid waste can have slightly more recoverable energy than a barrel of crude oil (Hay 1984), although the energy value is highly dependent upon the composition of the refuse.

In Europe, where land is at a premium and fossil fuel sources are limited, the incineration of municipal solid waste has been practiced for many years. In some communities as

much as 65 percent of the solid waste is incinerated in energy-from-waste (EFW) facilities (Hay 1984). In North America, 69 EFW plants were operating or under construction as of October, 1984 (Hanneman 1984). An additional 21 plants had been operating, but were closed down.

The incineration of municipal solid waste was once more common in Canada than it now is. Many older incinerators were shut down as more stringent environmental and health regulations were introduced during the 1970s. Subsequent advances in design have since produced safer and more efficient incinerators. Kidd (1984) reports that 15 municipal solid waste incinerators are operating in Canada (Table 8). Several others are in the planning stages. In Winnipeg, city officials are considering an incinerator for municipal solid waste with the capability of producing steam for heating the downtown core (D. Thompson 1985: pers. comm.).

The burning of refuse is conducted in many ways in Alberta. In rural areas, household waste is often burned in backyard barrels. Under the new Waste Management Regulation of the Public Health Act, refuse may be burned at any waste management facility if a permit is first obtained from the Local Board of Health. This practice was previously restricted to modified landfill sites.

Several Alberta municipalities are considering incineration as a component of their solid waste management systems. Work is underway for a modular incinerator to serve the

**Table 8. Municipal Solid Waste Incinerators in Canada**

| Location | Size (tonnes/day) | Energy/Materials Recovery |
|---|---|---|
| Duncan, B.C. | 45 | ? |
| Tumbler Ridge, B.C. | 15 | None |
| Kent, B.C. | 15 | ? |
| Ladysmith, B.C. | 15 | ? |
| Lake Cowichan, B.C. | 15 | ? |
| Toronto, Ontario | 810 | metal |
| Downsview, Ontario | 17 | steam/metal |
| Hamilton, Ontario | 540 | electricity/metal |
| Ajax, Ontario | ? | steam |
| Port Colborne, Ontario | ? | none |
| Collingwood, Ontario | ? | none |
| St. David, Quebec | 80 | metal |
| Montreal, Quebec | 1,080 | steam |
| Quebec City, Quebec | 920 | steam |
| Charlottetown, P.E.I. | 80 | steam |

Source : Kidd 1984 : Table 1-1

town of Wainwright and the surrounding region. The Lacombe Waste Management Authority also intends to incinerate its solid waste before disposal in a regional landfill. As more experience with incineration of solid waste is acquired in Alberta, other communities may consider this method of volume reduction.

From their national survey, Bird and Hale et al. (1979) reported a value of 18,470 kJ/kg (7,946 BTU/lb) for Alberta municipal solid waste. A study by the City of Edmonton determined the heat value of air-dried solid waste to be 15,611 kJ/kg (6,716 BTU/lb) (City of Edmonton 1978). These values are typical for municipal solid waste. In Table 9, the energy content of the materials found in municipal solid waste is listed. The energy content of the mixed refuse is comparable to Alberta Plains coal. Plastics have a very high energy content. Although the recovery of materials from the waste stream would reduce the quantity available for incineration, the energy value of the remaining material could be enhanced. Resource Integration Systems Ltd. (1980b) estimated that a materials recovery program for paper, glass, and ferrous metals would increase the heat value of municipal solid waste by 216 kJ/kg (93 BTU/lb).

Against the advantages of waste volume reduction and energy recovery, certain disadvantages of incineration must be weighed. The capital cost of incinerators is high and

**Table 9. Energy Content of Municipal Solid Waste and Alberta Coal**

| Municipal Solid Waste[1] | | Alberta Coal[2] | |
|---|---|---|---|
| | (kJ/kg) | | (kJ/kg) |
| Paper* | 18,874 | Mountain | 27,000 |
| Plastics | 39,262 | Foothills | 21,000 |
| Lumber | 19,793 | Plains | 17,400 |
| Putrescible | 20,150 | | |
| Textiles | 21,550 | | |
| Yard Waste | 15,160 | | |
| Mixed Refuse | 17,841 | | |

Sources : [1] Bird and Hale Ltd. et al. 1979
[2] Energy Resources Conservation Board 1981

*Average of several types of paper

The operation and maintenance of these units are important additions to waste management costs. Although an incinerator greatly reduces the volume of waste, it does not eliminate the need for landfilling. Ash and non-combustible material must still be disposed of. In addition, concerns have been expressed about the pollution produced by burning municipal solid waste. Of special concern are pollutants such as dioxins, furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), heavy metals, sulphur dioxide, and nitrogen oxides (Hay 1984). It has been suggested that "refuse incineration is the most significant controllable input of dioxin into the atmosphere" (Hay 1984: 2). While the emissions of some air contaminants, such as sulphur, are generally lower than from burning fossil fuels, other contaminants, such as lead, may be emitted in significant quantities (Freeman et al. 1981; Salas et al. 1981). Kidd (1984) has reviewed current information on emissions from municipal refuse incinerators.

The federal government has initiated the National Incinerator Testing and Evaluation Program to evaluate emissions from municipal waste incinerators and determine the most appropriate control technologies (Hay 1984). In addition, the Alberta Environmental Centre in Vegreville has an incinerator that will be used to investigate emissions and pollution control technologies for a variety of fuels and materials (A. Liem 1985: pers. comm.).

The use of municipal solid waste as a fuel source has been given consideration for Edmonton, but the prospect appeared to be uneconomical at the time (Webb 1983). The incinerators at Wainwright and Lacombe will not be designed to recover heat energy (T. Rogers 1985: pers. comm.). However, as technologies improve and economic factors change, advantage may be taken of this potential benefit of solid waste incineration.

## PYROLYSIS

As with incineration, pyrolysis can reduce the volume of municipal solid waste by about 90 percent. However, pyrolysis units have greater thermal efficiency, operate at a lower temperature, produce little if any air pollution, and produce potentially valuable products, such as pyrolytic oils and gases (Moell 1975). Furthermore, pyrolysis is compatible with the recovery of certain materials, such as metals and paper. The removal of paper products actually improves the value of municipal solid waste as a pyrolysis fuel because it increases the relative amounts of plastics and other organic wastes (Moell 1975).

Balanced against these very attractive characteristics, however, is the large capital cost of pyrolysis units. Furthermore, the pyrolysis of municipal solid waste is not yet firmly established in the North American market. Several pyrolysis systems have been investigated, but none of the North American pyrolysis facilities are still operating (Hay 1984). An attempt by the City of Lethbridge to test a pyrolysis unit in 1981/82 was unproductive. Technical problems prevented a proper evaluation and the project was abandoned (W. Brodowski 1985: pers. comm.). Thus the feasibility of solid waste pyrolysis is still uncertain.

## COMPOSTING

Large amounts of compost, an excellent soil conditioner, can be produced from municipal refuse. This process can complement the recovery of other materials, such as

metal, glass, and plastic. Nevertheless, large-scale composting of municipal solid waste has had little success in North America (Rimberg 1975). Economics appear to be unfavorable. Unlike most waste treatments that are expected only to reduce some of the costs of waste management, the production of compost is often expected to make profit or at least break even, an unlikely result (Golueke 1977). "One of the main reasons for the lack of a market for composted refuse is the generally poor quality of the product" (Golueke 1977: 12). Bits of plastic and glass are often found throughout the compost. These not only detract from its appearance, but also present a hazard to grazing animals if the compost is spread on pasture-land.

Composting in Alberta faces the disadvantage of long, cold winters. Large-scale, outdoor composting would probably be restricted to the summer months, unless some method of keeping the composting refuse warm could be devised. Another hindrance to composting of municipal refuse is that large-scale North American agriculture does not favor the use of bulky fertilizers or soil amendments (Golueke 1977). Better experience is found in Europe, especially in Holland and West Germany (Satriana 1974). Golueke (1977) reports that the successful composting of refuse in Mexico is due in part to a co-operative approach with the agricultural community.

# 6. SUMMARY

The quantity and composition of municipal solid waste varies according to several factors, such as population size, commercial and industrial activities, time of year, and so on. Generally speaking, every Albertan generates about 766 kg of solid waste each year. A large proportion of this (30 to 50 percent) consists of various forms of paper, such as newsprint, cardboard, and packaging material. Other valuable materials such as metals, plastics, and glass also end up in the waste stream.

The proper management of this material is becoming more and more sophisticated. In many Alberta communities, residential collection of solid waste is provided by the municipalities either by civic employees or private contractors. Service to single-family dwellings is often through curbside or back-alley pick-up. Multiple-family residences, commercial establishments, institutions, and industrial facilities are usually served by bulk container collection. Most of the refuse is taken directly to disposal sites; however, transfer stations are being used in the City of Edmonton and with many of the Province's regional landfill sites.

Although landfilling is still the predominant method of waste disposal in Alberta, it is not without problems. Landfill sites have limited capacities and the search for new sites is becoming more and more difficult. Environmental considerations and community rejection can greatly restrict the choice of potential sites. The high cost of land is another important obstacle. Municipalities are having to look further afield for landfill sites with the accompanying penalty of higher transportation costs.

What are the options for the future? The role of incineration in reducing the volume of waste that requires final disposal is receiving considerable attention. Currently there are plans for two solid waste incinerators in Alberta. The recovery of energy from the incineration of solid waste has a potential worthy of consideration.

But should this refuse be burned or is more extensive reuse of the materials feasible? There are many methods for recovering material from municipal solid waste, including curbside collection, recycling depots, and processing mixed refuse. Should recyclable material be diverted from the waste stream via at-source separation or should the mixed refuse be processed into fuel or compost? Which option or combination of options will provide the greatest benefits in the future course of waste management in Alberta? And, finally, which will be the most acceptable to the Alberta public? These and other questions should be considered by Albertans as they assist the provincial government in determining the proper role of recycling and resource recovery in Alberta's future.

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**Personal Communications**

Walter Brodowski, Mechanical Services Director, City of Lethbridge.

Jim Duckworth, City Engineer, City of Lloydminster.

John Ellacott, Manager, Foothills Conservation and Recycling Ltd.

Bill Higgins; Superintendent; Water and Sewer Section; Public Works Department, City of Red Deer.

Jim Lapp, Technologist, Waste Management Branch, Pollution Control Division, Alberta Environment.

Dr. Albert Liem; Head, Process Development; Environmental Technology Wing; Alberta Environmental Centre.

Siew Mak, Assistant City Engineer, Public Works Department, City of Medicine Hat.

Terry Montgomery, Operations and Development Engineer, Sanitation Division, Engineering Department, City of Calgary.

Roy Neehall, System Planning and Design Engineer, Department of Water and Sanitation, City of Edmonton.

Tom Rogers, Assessment Head, Waste Management Branch, Pollution Control Division, Alberta Environment.

Dave Thompson, Waste Management, Manitoba Environment and Workplace Safety and Health.

Bill Tuttle, City Engineer, City of Grande Prairie.

Fred Zaal, Impact Assessment Biologist, Environmental Protection Service, Environment Canada, Edmonton.